Trace Elements:
Selenium

Selenium is a trace mineral essential to good health. The major dietary source of selenium is plant foods. Selenium concentrations in plants generally reflect the concentration of selenium in soils, but some meats and seafood can also contribute dietary selenium; in the United States, meats and bread are common sources. Depending on foodstuff origin, variation in its selenium content can be between 11- and 72-fold; thus, predicting dietary intake by relying on estimates from nutrient databases is difficult (Keck 2006).

Selenium functions through selenoproteins, several of which are oxidant-defense enzymes. For example, the selenium-dependent glutathione peroxidase defends the body against oxidative stress. Other selenium-associated proteins regulate the action of thyroid hormones and the oxidation-reduction status of vitamin C and other molecules (Institute of Medicine 2000). Most selenium in animal tissues is present as selenomethionine or selenocysteine.

Selenium deficiency in the United States is rare, but it is seen in other countries, most notably in China, where the concentration of selenium in soil is low. In the United States, most cases of selenium depletion or deficiency are associated with severe gastrointestinal problems, such as Crohn's disease, or with the surgical removal of part of the stomach, and are therefore a result of impaired selenium absorption (Kuroki 2003; Rannem 1992; Bjerre 1989).

By itself, selenium deficiency does not usually cause illness. Rather, it can make the body more susceptible to illnesses caused by other nutritional, biochemical, or infectious stresses (Beck 2003). Three specific diseases have been associated with selenium deficiency. Keshan disease occurs only in selenium-deficient children and is associated with an enlarged heart and poor heart function. Kashin-Beck disease is a disorder of the bones and joints of the hands and fingers, elbows, knees, and ankles of children and adolescents. Lastly, myxedematous endemic cretinism, a condition that results in mental retardation, occurs in infants born to mothers deficient in both selenium and iodine (Institute of Medicine 2000).

Chemists review selenium data.

Evidence is limited as to whether intakes of selenium greater than the amount needed to allow full expression of selenoproteins may have chemopreventive effects against cancer. Controlled intervention studies are needed to adequately evaluate selenium as a cancer chemopreventive agent (Institute of Medicine 2000).

Blood concentrations of selenium greater than 1,000 nanograms per milliliter (ng/mL) (12.7 micromoles per liter [µmol/L]) can result in a condition known as selenosis (Koller 1986). Manifestations of selenosis include gastrointestinal upset, hair loss, white blotchy nails, garlic-breath odor, fatigue, irritability, and mild nerve damage (Goldhaber 2003).

The National Academy of Sciences has established an estimated average requirement (EAR) for selenium that is based on the amount needed to maximize plasma glutathione peroxidase activity and prevent Keshan disease. The EAR is the average daily nutrient intake level estimated to meet the requirement of half of the healthy individuals in a particular life stage and sex group. The EAR for selenium for boys and girls 9–13 years old or 14–18 years old is 35 and 45 micrograms (µg) daily, respectively. For healthy children aged 1–3 years or 4–8 years, the currently recommended EAR for selenium is 17 and 23 µg daily, respectively. These values are extrapolated from adult values (Institute of Medicine 2000).

A diagnosis of selenium deficiency is confirmed by measuring concentrations of selenium in serum or plasma. Values less than 70 ng/mL or 0.8 µmol/L suggest synthesis of selenium-associated proteins has not yet reached a plateau and that selenium supplies are limited (Institute of Medicine 2000).

For more information about selenium, see the Institute of Medicine's Dietary Reference Intake report (Institute of Medicine 2000), the selenium fact sheet from the National Institutes of Health, Office of Dietary Supplements (http://ods.od.nih.gov/factsheets/selenium.asp), as well as information from the American Society for Nutrition (http://jn.nutrition.org/nutinfo/).

Using serum selenium concentrations measured in the U.S. population in NHANES III (1988–1994), it appears that the diets of most U.S. residents provide the recommended amounts of selenium (Niskar 2003). The mean and median serum selenium concentrations were 1.58 µmol/L and 1.56 µmol/L, respectively. Serum selenium concentrations differed by age, sex, race, ethnicity, poverty-income ratio, and geographic region. In NHANES 2001–2002, less than 3 percent of survey participants had a dietary intake of selenium below the EAR (Moshfegh 2005).

Selected Observations and Highlights

The following example observations are taken from the tables of 1999-2000 data contained in this report. Only data for children were available for the NHANES survey period covered in this report. Statements about categorical differences between demographic groups noted below are based on non-overlapping confidence limits from univariate analysis without adjusting for demographic variables (i.e., age, sex, race/ethnicity) or other determinants of these blood concentrations (i.e., dietary intake, supplement usage, smoking, BMI). A multivariate analysis may alter the size and statistical significance of these categorical differences. Furthermore, additional significant differences of smaller magnitude may be present despite their lack of mention here (e.g., if confidence limits slightly overlap or if differences are not statistically significant before covariate adjustment has occurred). For a selection of citations of descriptive NHANES papers related to these biochemical indicators of diet and nutrition, see Appendix E.

General Observations

- Younger children (aged 3–5 years) have lower serum selenium concentrations than do older children (aged 6–11 years).
- At least 90 percent of 3–11 year-old children have adequate serum concentrations of selenium.

Highlights

The majority of U.S. children (> 90 percent) have adequate serum concentrations of selenium (≥ 70 ng/mL). No evidence has surfaced of excessive exposure to selenium (> 1,000 ng/mL) in U.S. children.

Table 4.2.a. Serum selenium: Total population

Geometric mean and selected percentiles of serum concentrations (in ng/mL) for the total U.S. population aged 3 years and older, National Health and Nutrition Examination Survey, 1999–2000.

	Geometric mean (95% conf. interval)	Selected percentiles (95% conf. interval)			Sample size
		10th	50th	90th	
Males and Females					
Total,3-11 years	112 (110-114)	93.0 (91.0-96.0)	113 (111-114)	130 (127-133)	1186
3–5 years	107 (104-110)	90.0 (83.0-94.0)	110 (105-112)	128 (124-131)	343
6–11 years	114 (111-116)	95.0 (93.0-102)	113 (111-116)	130 (128-134)	843
Males					
Total,3-11 years	113 (110-116)	94.0 (91.0-98.0)	114 (111-116)	134 (129-137)	626
3–5 years	108 (103-112)	87.0 (64.0-95.0)	108 (104-112)	129 (123-136)	188
6–11 years	115 (111-119)	96.0 (91.0-104)	114 (110-121)	134 (129-137)	438
Females					
Total,3-11 years	111 (108-113)	93.0 (90.0-96.0)	112 (110-116)	128 (126-131)	560
3–5 years	107 (102-111)	89.0 (72.0-96.0)	110 (105-115)	126 (119-131)	155
6–11 years	112 (109-115)	93.0 (89.0-98.0)	113 (109-117)	128 (126-131)	405

Table 4.2.b. Serum selenium: Mexican Americans

Geometric mean and selected percentiles of serum concentrations (in ng/mL) for Mexican Americans in the U.S. population aged 3 years and older, National Health and Nutrition Examination Survey, 1999–2000.

	Geometric mean (95% conf. interval)	Selected percentiles (95% conf. interval)			Sample size
		10th	50th	90th	
Males and Females					
Total,3-11 years	110 (107-113)	93.0 (87.0-96.0)	109 (106-113)	126 (123-131)	477
3–5 years	108 (104-112)	90.0 (83.0-98.0)	107 (103-113)	124 (120-129)	131
6–11 years	111 (108-114)	95.0 (91.0-100)	111 (107-114)	128 (123-133)	346
Males					
Total,3-11 years	111 (108-115)	93.0 (85.0-98.0)	111 (108-114)	129 (125-135)	262
3–5 years	109 (105-113)	87.0† (83.0-99.0)	108 (104-114)	125† (120-135)	71
6–11 years	112 (109-116)	93.0 (87.0-100)	111 (107-115)	133 (126-135)	191
Females					
Total,3-11 years	108 (105-112)	95.0 (89.0-98.0)	108 (105-114)	123 (118-126)	215
3–5 years	106 (100-112)	89.0† (76.0-98.0)	105 (100-112)	123† (116-130)	60
6–11 years	109 (106-112)	96.0 (87.0-99.0)	111 (105-114)	123 (118-132)	155

† Estimate is subject to greater uncertainty due to small cell size.

Table 4.2.c. Serum selenium: Non-Hispanic blacks

Geometric mean and selected percentiles of serum concentrations (in ng/mL) for non-Hispanic blacks in the U.S. population aged 3 years and older, National Health and Nutrition Examination Survey, 1999–2000.

	Geometric mean (95% conf. interval)	Selected percentiles (95% conf. interval)			Sample size
		10th	50th	90th	
Males and Females					
Total,3-11 years	107 (104-110)	91.0 (87.0-94.0)	107 (104-111)	124 (120-126)	341
3–5 years	104 (101-107)	91.0† (84.0-94.0)	104 (102-109)	121† (116-125)	98
6–11 years	108 (105-112)	92.0 (87.0-94.0)	108 (105-112)	124 (121-130)	243
Males					
Total,3-11 years	108 (105-112)	91.0 (86.0-94.0)	109 (104-113)	124 (118-130)	173
3–5 years	104 (99.4-109)	83.0† (50.0-91.0)	105 (103-112)	118† (113-131)	56
6–11 years	110 (106-115)	92.0 (86.0-101)	110 (105-115)	126 (119-133)	117
Females					
Total,3-11 years	106 (104-108)	91.0 (87.0-95.0)	107 (103-109)	122 (118-124)	168
3–5 years	105 (101-109)	93.0† (84.0-96.0)	103 (98.0-112)	120† (112-127)	42
6–11 years	106 (104-109)	92.0 (87.0-96.0)	106 (103-110)	121 (118-124)	126

† Estimate is subject to greater uncertainty due to small cell size.

Table 4.2.d. Serum selenium: Non-Hispanic whites

Geometric mean and selected percentiles of serum concentrations (in ng/mL) for non-Hispanic whites in the U.S. population aged 3 years and older, National Health and Nutrition Examination Survey, 1999–2000.

	Geometric mean (95% conf. interval)	Selected percentiles (95% conf. interval)			Sample size
		10th	50th	90th	
Males and Females					
Total,3-11 years	113 (110-116)	94.0 (90.0-102)	116 (112-118)	130 (127-135)	265
3–5 years	107 (102-113)	87.0† (57.0-103)	114 (105-118)	130† (123-133)	81
6–11 years	115 (111-119)	94.0 (90.0-104)	116 (111-120)	131 (127-136)	184
Males					
Total,3-11 years	113 (109-118)	93.0 (91.0-102)	114 (109-121)	134 (128-137)	140
3–5 years	106 (98.9-114)	87.0† (57.0-99.0)	105 (99.0-122)	125† (123-135)	41
6–11 years	116 (110-122)	102† (84.0-110)	115 (110-123)	134† (129-139)	99
Females					
Total,3-11 years	112 (108-117)	94.0 (80.0-102)	116 (111-119)	130 (126-132)	125
3–5 years	108 (101-117)	80.0† (33.0-107)	114 (107-118)	130† (120-133)	40
6–11 years	114 (109-119)	93.0† (79.0-105)	118 (110-120)	130† (126-135)	85

† Estimate is subject to greater uncertainty due to small cell size.

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